1. **Title Page**

a. **Project Title**: Evaluating the structural and functional equivalency of natural and restored oyster reefs in the North Carolina National Estuarine Research Reserve

b. **Reserve Project Site**: North Carolina National Estuarine Research Reserve
Priority Management Need Addressed: 1) Species and habitat restoration/enhancement, 2) Ecosystem services

c. **Project Period**: August 1, 2020 – July 31, 2022

d. **Applicant**:
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f. **Anticipated Graduation Year**: 2022

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FY20-21: $60,000.00
FY21-22: $60,000.00

k. **NOAA Cooperative Institute**: NA

Project Narrative Attachment Form [V1.2]

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2. Statement of Interest

I am an advocate by nature and a scientist by choice. In both my personal and professional life I seek to serve people and work on projects that are overlooked, misunderstood, or otherwise lack priority. Because my brother Art has Down syndrome, autism, and is functionally non-verbal, I am well-acquainted with the broad inaccessibility to traditional science education for minorities, especially alter-abled people like Art. Thus, my underlying mission is to collaboratively pursue an understanding of the natural world and to serve others through inclusive and equitable science education.

Current academic status: Presently, I am a 2nd-year doctoral student at the University of North Carolina at Chapel Hill with affiliations to the Environment, Ecology, and Energy Program and the Institute of Marine Sciences. Prior to matriculating at UNC, I earned my MSc in Biology at the University of Oregon's Institute of Marine Biology. I also served an AmeriCorps year as a Citizen Science Educator, which included supporting 10+ volunteer data collection programs in the lab and field and leading a 3-month NOAA Bay and Watershed Education Training Program on ocean acidification for high schoolers. At UNC, I have completed my coursework, assembled a full committee, and developed a cohesive dissertation framework (see below). My goal to advance to candidacy in Spring 2020.

Research interests, proposed research fit: Broadly, I am interested in research exploring applied ecology, historical ecology, and coastal ecosystem responses to human-mediated change. For my first master's thesis chapter, I collaborated with managers and scientists at the Oregon Department of Fisheries and Wildlife and the United States Forest Service to analyze a dataset that monitored a nascent *Didemnum vexillum* population at an oyster farm. Our manuscript of this research is in review at *Aquatic Ecology*. We report evidence that *D. vexillum*'s erratic fluctuation in cover was related to season and salinity. In my second chapter, I determined that another invasive tunicate, *Botrylloides violaceus*, does not have a significant impact on the growth, condition, or meat quality of oysters and mussels. A major theme of my doctoral research is oyster-pest dynamics—it is thus a natural extension of my master's work.

My dissertation centers on oyster reef restoration trajectories in Pamlico Sound and Chesapeake Bay. For my first two chapters, I am collaborating with scientists and officials at the North Carolina Division of Marine Fisheries (NCDMF) to analyze a complex, long-term monitoring dataset from the NC Oyster Sanctuary Program (OSP), a network of subtidal spawning sanctuaries. I described decadal network- and individual sanctuary-level oyster population trajectories. Additionally, I found that sanctuaries characterized by higher mean salinities (> 17 psu) had a greater prevalence of bioeroding clionid sponges, and their oyster populations subsequently collapsed within five years of substrate deployment. I am currently writing a manuscript of these findings (Chapter 1). I recently secured $145,722 through NCDMF's Coastal Recreational Fishing License grant program to evaluate and optimize restoration targets and multi-substrate monitoring methods for the OSP (Chapter 2). Last summer, I earned and completed a prestigious Smithsonian Institution Fellowship. Based at the Smithsonian Environmental Research Center, I collected data to assess bioeroding parasite (i.e., *Cliona* spp. and mud blister worms, *Polydora* spp.) and oyster population structures in restored subtidal Chesapeake Bay oyster reefs (Chapter 3). The study I propose here seeks to evaluate the structural and functional equivalency of natural and restored oyster reefs in the Rachel Carson Reserve (Chapter 4). Because these reefs are intertidal, this chapter will offer a complementary yet distinct look at oyster reef restoration trajectories, thereby rounding out my overarching dissertation narrative.

Career goals, interest in Davidson professional development opportunities: My long-term career goal is to work in science communication or evidence-based policymaking at the federal level—for example, at NOAA. I am applying for the Margaret A. Davidson Graduate Fellowship for the National Estuarine Research Reserve System because it is a program at the nexus of research, monitoring, stewardship, and education that will further develop the leadership skills I need to champion my career goals. I particularly look forward to the opportunities to network with the fellowship class and receive multidisciplinary mentorship. Coupled with my resilience and project management skills, my demonstrated ability to foster and maintain productive, collaborative partnerships at a diversity of organizations—ranging from Woods Hole Oceanographic Institution to small non-profit aquaria and the federal government—have prepared me for success as a Davidson Fellow and beyond.

3. Project Summary

a. Project Title: Evaluating the structural and functional equivalency of natural and restored oyster reefs in the North Carolina National Estuarine Research Reserve

b. Reserve Project Site: North Carolina National Estuarine Research Reserve

c. Summary:

Priority Management Need Addressed: 1) Species and habitat restoration/enhancement, 2) Ecosystem services

Project Objectives: The objectives of this study are to quantify, evaluate, and compare the structural and functional attributes of natural reference and restored intertidal oyster reefs, and estimate the time required for the restored reefs to reach structural and functional equivalency with or outperform natural reefs. I am especially interested in identifying what biophysical factors (e.g., depth, pest presence and prevalence) are the most important mechanistic drivers of the patterns we observe, and pinpointing what conditions are most conducive to long-term oyster restoration success and maximizing the potential delivery of two major ecosystem services, filtration and fish production.

Expected Results: This longitudinal study will collect data on restored oyster reef 1) structure—reef area and height, oyster density, biomass, size-frequency distribution, growth rates, and survival; and 2) function—filtration potential, community assemblage, functional diversity. It is designed to elucidate how and why restored reefs of different ages (4, 9, 20, 23 years) change in structure and function through time; I also expect learn how these recovery patterns track to nearby natural reefs and estimate the amount of time it takes for restored reefs to meet or surpass the structure and function of natural reefs (based on the available literature, I hypothesize ~3 years). To compare the patterns comprehensively, I will use permutation tests for multivariate analysis of similarity. The data I propose to collect will also be usable in the Nature Conservancy's Oyster Calculator tool, which will allow me to evaluate the amount of additional oyster habitat that would be required to achieve specific ecosystem service targets and streamline the comparison of my findings to other sites. I anticipate delivering a comprehensive final report, 3 technical progress reports, and a dissertation chapter and peer-reviewed paper. In addition to fully describing all statistical analyses in these reports, I will submit the R scripts associated with each analysis and make the data publicly available per our Data Sharing Plan (Appendix 6e).

Intended Benefits and Outcomes: Applying an understanding of how restored oyster reefs recover the structure and function of natural reefs through time, even if the baseline functions of natural reefs have shifted, will inform project trajectory expectations of future intertidal oyster restoration projects in North Carolina. Our current understanding of the 'lifespan' of restored oyster reefs is limited, and identifying the biophysical factors underpinning those lifespans is critical to informing future restoration siting. Further, quantifying the ecosystem services—in this case, the functional diversity the reefs support and their filtration capacity—is a stated management need of the NCNERR and a recommendation in the 2018-2020 implementation plan of the North Carolina Coastal Habitat Protection Plan. Additional agencies with a vested interest in the results of this project include the NC Coastal Federation, NC Divisions of Marine Fisheries and Coastal Management, The Nature Conservancy, NC Sea Grant, and NOAA/NERRS. All of these organizations are partners of the oyster blueprint platform, which connects diverse stakeholders to current information on oyster efforts in North Carolina. In addition to sharing my findings and reports on that platform directly, I will connect with the local resource managers and growers who our lab and the NCNERR have previously collaborated or currently collaborate with to further share the anticipated findings and reports. Moreover, I will maintain my commitment to inspiring estuarine stewardship in the broader community, especially youth. I will co-develop a unit on oyster reefs with teachers at Beaufort and Morehead City Middle Schools. The unit will fulfill "MS-LS2: Ecosystems: Interactions, Energy, and Dynamics" learning objectives, and I will share it with other local educators at Scientific Research and Education Network (SciREN) events and make the lesson plans publicly available on the NCNERR Educator Resources website.

4. Project Description

a. Problem Statement and Background Information

Statement of the Problem: Estuaries in eastern North America were once replete with the eastern oyster *Crassostrea virginica*, an iconic ecosystem engineer that fueled coastal economies for centuries. A suite of chronic stressors—including historic overharvesting [1,2], habitat degradation [3], sedimentation [4], and disease [5]—are largely responsible for remarkable oyster declines [2]. Losses in oyster reef habitat and biomass over the past century in eastern North America are estimated at 64% and 88%, respectively [6]. Coupled with these losses are the depreciation of the ecosystem services oysters provide, including the provision of refugia from predators, feeding and nursery habitat, direct harvest value, biofiltration, nutrient reductions, and shoreline armoring [7,8]. Oyster restoration projects seek to recover these services [9].

Broadly, a major restoration goal is achieving equivalence in structure and function between natural and restored habitats [10]. While several direct assessments of aspects of these equivalencies exist for subtidal oyster reefs [11–15], they vary regionally and temporally. For example, one study in the Chesapeake Bay found that non-oyster faunal densities were significantly higher in restored plots than natural plots after 3-5 years [13]; another in Mississippi found constructed reefs surpassed natural reefs in oyster density, taxa richness, and faunal abundance after only 2 years. Fewer studies have considered the structural and functional equivalencies of intertidal oyster reefs. A study in South Carolina suggested that the faunal composition of constructed reefs was less diverse than natural reefs after 7 years, but did not examine reef structure [11]. In North Carolina, Theuerkauf [16] and Brodeaur [17] suggested that conserving natural intertidal reefs should be a management priority because they host more abundant oyster populations than hardened shorelines. Whereas community composition assessments are absent from those studies, Keller [18] included oyster populations *and* associated fauna and found few differences between constructed and natural salt marsh-fringing reefs after 2 years.

The historical record attributes parasitic bioeroders, including boring sponges (*Cliona* spp.) and mud blister worms (*Polydora* spp.), to oyster reef collapse [19–21]. These bioeroders further exacerbate oyster stress as they excavate oysters' calcium carbonate shells [22,23], forcing oysters to divert energy from growth and reproduction to shell maintenance and lowering their condition and survival [24–26]. In North Carolina, clionid sponges are a documented problem for oyster demographic rates in subtidal [27,28] and intertidal [29] reefs. Studies have demonstrated that oyster demographic rates are dynamic and density-dependent [30,31]. Oyster demography is also related to vertical reef accretion and reef persistence [32], and thus positive demographic rates are necessary for restored reefs to achieve equivalency to natural reefs. Given the negative impacts bioeroding parasites have on oyster demographic rates, bioeroder prevalence may be an important predictor of restoration trajectories.

North Carolina boasts a rich and recent history of both sub- and intertidal oyster restoration research [16–18,30,33–39]. But given the aforementioned studies' divergent findings, a more comprehensive examination of the equivalencies amongst intertidal natural and restored oyster reefs is clearly merited. **Reefs built over the past 2+ decades in the Rachel Carson Reserve** [34,35,39] **offer a rare opportunity to compare attributes of restored intertidal oyster reefs of varying ages to natural reference reefs. A longitudinal study that quantifies oyster restoration trajectories may clarify if and when restored intertidal reefs meet—or even surpass—natural reefs in structure and function. Such a study may also identify the biophysical factors that drive the patterns in oyster habitat recovery and, by extension, the provisioning of oyster reef ecosystem services in the North Carolina National Estuarine Research Reserve (NERR), the NERR System, and beyond.**

Background: Highly variable success criteria further complicate the evaluation of oyster reef restoration. Compared to other coastal biogenic habitats, oyster reefs are unique in that, until lately, their restoration initially focused on augmenting fisheries loss, and thus success criteria primarily reflected fisheries-based metrics such as abundance of market-sized (> 75mm) oysters [40]. More recently, Baggett et al. [41] recommended four universal restoration performance criteria regarding physical and population structure: reef areal dimensions, reef height, oyster density, and oyster size-frequency distribution.

However, success criteria that evaluate the community function of restored oyster reefs are equally critical for a holistic evaluation of their performance. Previous studies have used benthic macrofaunal (i.e., prey resource), juvenile fish, and piscivorous fish (i.e., predator) composition through time as a metric for assessing community functional equivalence [13,14,39].

From 1997-2016, scientists at the University of North Carolina Institute of Marine Sciences (IMS) built a substantial number of experimental oyster reefs in and around the Rachel Carson Reserve to answer a multitude of ecological and biogeochemical research questions. Importantly, these studies have determined that a vertical 'hotspot' exists for oyster biomass accumulation between -0.5 and -0.6 m NAVD88 [34], and that restored reefs on mud flats support higher oyster biomass and faunal densities than those adjacent to seagrass beds and salt marshes [39,42]. I propose to return to sites on mudflats at mid-depth levels that are 4, 9, 20, and 23 years old. In October 2019, I observed live *Cliona* spp. tissue infecting oysters from at least one reef from every age group, and thus a consideration of the roles bioeroders play in recovery patterns is warranted.

The objectives of this study are to quantify, evaluate, and compare the structural and functional attributes of natural reference and restored intertidal oyster reefs, and estimate the time required for the restored reefs to reach structural and functional equivalency with or outperform natural reefs. I am especially interested in identifying what biophysical factors (e.g., depth, pest presence and prevalence) are the most important mechanistic drivers of the patterns we observe, and pinpointing what conditions are most conducive to oyster restoration success and optimizing ecosystem service delivery. Long-term oyster restoration trajectories are not well-studied, nor are they included in the NERRS System-Wide Monitoring Program (SWMP). Thus, **this research directly addresses two of the North Carolina NERR's coastal management research priorities, namely the evaluation of oyster habitat restoration practices and subsequent ecosystem services they deliver.** Specifically, I aim to combine the results of this and previous studies [18,34,39,42] to recommend siting conditions most suitable for long-term oyster reef recovery and maximizing potential filtration and fish production.

b. Project Approach

Proposed natural reference reefs and restored reefs are located on sand/mud flats within Middle Marsh (Table 1). I selected these reefs because they all reside in the same seascape context and span a relatively narrow elevation gradient (-0.385 to -0.660 m). While some experimental Middle Marsh reefs are sedimented over and no longer exist, I have recent (Fall 2019) confirmation that these reefs are still present. Davidson-funded sampling will occur in late September 2020, May 2021, and September 2021, but my collaborators and I also have plans to sample in May 2020 (Table 2).

Question 1 – Structure: a) How do the physical reef and oyster demographic structures—reef area and height, oyster density, biomass, size-frequency distribution, growth rates, and survival—of natural reference and restored oyster reefs change through time? b) For restored reefs, what is the estimated time-to-structural equivalence to reference reefs? c) What environmental site conditions favor bioeroders, and what is the relationship between bioeroder pest prevalence and reef structure? If bioeroders recruit to and infect juvenile oysters, how long post-settlement does recruitment occur?

- H_{a1}: a) Physical reef traits are positively and logistically correlated with reef age and depth. b) Oyster demographic structures are significantly different between reefs of different ages, and these demographic structures converge with or outperform natural reefs ~3 years after their establishment. c) Reefs that are deeper and have lower demographic rates will be more prone to bioeroder infection, and reefs with higher bioeroder prevalence have lower demographic rates.

Method: I will survey reef height using a Trimble GPS, and measure reef dimensions to estimate reef area. To determine oyster densities and size-frequency distributions, I will hand excavate a randomly placed 0.25 m^2 quadrat at the crest and slope of the reef. Then, I will weigh the excavated contents and measure and sort oysters into 1-cm length bins [33]. To evaluate bioeroder prevalence, if an oyster is infected with sponge I will measure the length of the left valve that is perforated and note whether the sponge tissue is active or dormant [43]. If oysters in a sample appear infected with *Polydora* spp., I will

subsample individual oysters (n = 30) to leave in individual containers of still water for 24 hours, after which I will count the abundance of worms that evacuated each oyster's shell. I will perform the excavation methods in early May and late September to bookend the primary oyster spawning periods. I ground-truthed these excavation methods in October 2019. I am keeping my quadrat sample size low (n = 2 per survey per reef) because the reefs are generally small (planting size: ~3 m x ~ 5 m) and I thus seek to minimize my impact on sensitive habitat.

Methods for quantifying growth rates and survival are adapted from Puckett and Eggleston [30]. Briefly, I will build and deploy a settlement tray near the top of each reef (n = 15) in early May. Each month through October, I will randomly mark up to n = 20 individuals with numbered Betterbee® queen bee tags before digitally photographing the trays and measuring both the newly and previously marked individuals with digital calipers. The tags will allow me to track the lengths and fate of individuals in each monthly 'settlement cohort', look for the presence and prevalence of any boring sponge (*Cliona* spp.) or mud blister worm (*Polydora* spp.) recruitment, and calculate survivorship through time.

Table 1. Plant years, elevations, and locations of reefs proposed to sample.

Plant year	Elevation (m)	Latitude	Longitude	ID, previous study	Age in 2020	Citation
1997	-0.500	34.6937	-76.6198	MF1_97	23	Grabowski, 2005
1997	-0.660	34.6929	-76.6221	MF2_97	23	Grabowski, 2005
1997	-0.517	34.6850	-76.6125	MF3_97	23	Grabowski, 2005
2000	-0.500	34.6930	-76.6202	MF1_00	20	Grabowski, 2002
2000	-0.553	34.6927	-76.6208	MF2_00	20	Grabowski, 2002
2000	-0.522	34.6852	-76.6121	MF3_00	20	Grabowski, 2002
2011	-0.515	34.69782	-76.61441	1S5	9	Fodrie et al., 2014
2011	-0.475	34.68796	-76.61888	2S5	9	Fodrie et al., 2014
2011	-0.513	34.68818	-76.61968	2S6	9	Fodrie et al., 2014
2016	-0.385	34.68948	-76.61777	CCA2	4	unpublished
2016	-0.503	34.68978	-76.61842	CCA3	4	unpublished
2016	-0.508	34.68815	-76.61140	CCA7	4	unpublished
natural	TBD	34.69849	-76.60833	NA	unknown	NA
natural	TBD	34.69188	-76.61858	NA	unknown	NA
natural	TBD	34.69073	-76.62003	NA	unknown	NA

Question 2 – Function: a) How does the community assemblage and functional diversity of natural reference and restored oyster reefs change through time, and what factors drive these patterns? b) What amount of time does it take for restored reefs to achieve functional equivalency to natural reference reefs, regardless of how the natural reefs are performing?

- H_{a2}: a) Functional group density, biomass, and diversity are positively and logistically correlated with depth and reef structure. b) Restored reefs reach functional equivalence to or surpass natural reefs ~3 years post-planting.

Method: The following methods are adapted from Grabowski [39] and Rodney and Paynter [13] to quantify prey resources, juvenile fish, and piscivorous fish (i.e., predators). I will sample for prey resources during the quadrat sampling outlined in Question 1. Specifically, I will first subsample a 15 cm core on each plot down to 10 cm for polychaetes, amphipods, and other infauna. Then, I will identify, count, and measure the free-living invertebrate macrofauna and epifauna within the rest of the excavated quadrat material. To assess juvenile fish abundance patterns, I will deploy minnow traps (n = 2) at each reef for ~6 hours between midflood and midebb tide each month from May through October around the full moon. During those deployments, I will also place a gill net (n = 1, 10 m × 1.5 m, with 7.5 cm slit openings) at each reef to quantify piscivorous fish. Upon trap and net collection, I will measure, count,

and identify the organisms captured in the minnow traps and gill nets to species; I will also weigh the piscivorous fish. Further, I will assign each organism to one of four functional feeding groups [11]: deep deposit feeders, surface deposit feeders, suspension feeders, and carnivores/omnivores. Finally, I will also estimate the filtration capacity of the reefs using quadrat-excavated oysters following La Peyre et al. [44].

Statistical Analysis and Work Products: Following the recommendation of Walters and Coen [11], I will test the above hypotheses using permutation tests for multivariate analysis of similarity (PERMANOVA, R package 'vegan'). The authors compared a number of classical and non-parametric analytic approaches for comparing natural and restored oyster reefs and deemed the PERMANOVA approach as the most flexible and powerful. Provided the expectation that restored reefs will rapidly reach accretion equilibrium with sea level [38], that I do not have historical reef height data for the natural reefs will not limit this project. The work products anticipated for this project include: a comprehensive final report, which I will prepare with the guidance of an NCNERR mentor and Research Coordinator Dr. Brandon Puckett; 3 technical progress reports (delivered every 6 months, Table 2); a dissertation chapter manuscript, which will ultimately be submitted to an academic journal for peer-review in a timely fashion. In addition to fully describing all statistical analyses in these reports, I will submit the R scripts associated with each analysis. I elaborate on the planned dissemination of my findings below.

c. Expected Outcomes

Applying an understanding of how restored oyster reefs recover the structure and function of natural reefs through time, even if the baseline functions of natural reefs have shifted, will inform project trajectory expectations of future intertidal oyster restoration projects in North Carolina. Our current understanding of the 'lifespan' of restored oyster reefs is limited, and identifying the biophysical factors underpinning those lifespans is critical to informing future restoration siting. Further, quantifying the ecosystem services—in this case, the functional diversity the reefs support and their filtration capacity—is a stated management need of the NCNERR and a recommendation in the 2018-2020 implementation plan of the North Carolina Coastal Habitat Protection Plan [45].

Fish production and water filtration are the two ecosystem services used in The Nature Conservancy's Oyster Calculator [46]. Thus, I will use that tool to evaluate the amount of additional oyster habitat that would be required to achieve specific ecosystem service targets—information that will be of considerable value to the agencies charged with planning and managing oyster habitat restoration projects. These agencies include the NC Coastal Federation, NC Divisions of Marine Fisheries and Coastal Management, The Nature Conservancy, NC Sea Grant, and NOAA/NERRS. All of these organizations are partners of the oyster blueprint platform, which connects diverse stakeholders to current information on oyster efforts in North Carolina; I will share my findings and reports on that platform directly. Early on in the study, I will connect with the local resource managers and growers with whom our lab has previously collaborated or currently collaborate with to incorporate their diverse perspectives into any outcome or product decision-making. Our lab also has a reliable record of posting work and media of experiments via the internet through the IMS webpage.

Core to my personal research philosophy is the inclusion and engagement of individuals outside of academia in the scientific process. I have demonstrated a commitment to this ideal prior to and within graduate school as a citizen science educator at the Port Townsend Marine Science Center (WA) and teaching fellow at the Charleston Marine Life Center (OR). Drawing upon my background in K-12 Next Generation Science Standards-aligned curriculum design, I will co-develop a unit on oyster reefs with teachers at Beaufort and Morehead City Middle Schools. The unit will fulfill "MS-LS2: Ecosystems: Interactions, Energy, and Dynamics" learning objectives, and I will share it with other local educators at Scientific Research and Education Network (SciREN) events and make the lesson plans publicly available on the NCNERR Educator Resources website. Throughout the rest of my PhD as a Davidson Fellow, I will continue to participate in the Skype a Scientist match program that fosters communication between scientists and classrooms across the nation, through which I have connected with over 300 K-12 students in 8 states over the past year. I will also continue to be involved in the Girls Exploring Science and Technology programs at IMS and the Duke University Marine Lab as either a coordinator or activity

leader. Provided my extensive experiences in oyster research and science education and communication, I am uniquely qualified to conduct this study and associated outreach.

In sum, this project—and more broadly, my dissertation—will ultimately benefit the marine and estuarine resources of North Carolina by providing the NCNERR and other stakeholders insight into what factors drive the long-term trajectories of restored oyster reefs and the ecosystem services they provide Pamlico Sound. Thus, there is compelling reason for financial support of this work.

d. Milestone Schedule

Table 2. Milestone schedule for major tasks by budget year. Project tasks that are sponsored by non-Davidson funding are denoted with ***.

FY	Month and Year	Quadrat excavation	Survey physical reef structure	Sample oyster demogr. structure	Assess fish abund.	Analyze data	Prepare progress reports	Write final report/ manuscript and defend dissertation
***	May 2020	X	X	X	X			
	June 2020			X	X			
	July 2020			X	X			
Y1: 2020-2021	Aug 2020			X	X			
	Sept 2020	X	X	X	X			
	Oct 2020					X		
	Nov 2020					X		
	Dec 2020					X		
	Jan 2021					X	X	
	Feb 2021					X		
	Mar 2021					X		
	April 2021					X		
	May 2021	X	X	X	X			
	June 2021			X	X			
	July 2021			X	X	X	X	
Y2: 2021-2022	Aug 2021			X	X			
	Sept 2021	X	X	X	X			
	Oct 2021					X		
	Nov 2021					X		
	Dec 2021					X		
	Jan 2022					X	X	
	Feb 2022							X
	Mar 2022							X
	April 2022							X
	June 2022							X
	July 2022							X

5. Budget Narrative and Justification

Table 3. Davidson Fellowship budget separated by award year.

Category	Year 1 (08/20-07/21)		Year 2 (08/21-07/22)		Total
Student-Related Costs	**Effort**		**Effort**		
Graduate student salary (12 mo)	95%	$25,520	94%	$25,337	$50,857
Graduate student health insurance (12 mo)		$3,818		$3,904	$7,722
Graduate student benefits (1.34% of salary)		$342		$340	$681
Graduate student tuition and fees		$6,848		$7,003	$13,850
Subtotal		$36,527		$36,583	$73,110
Indirect costs:		$16,472		$16,417	$32,889
Travel					
Annual Fellow Meeting		$2,251		$2,251	$4,502
National Meeting (Y1: NERRS, Y2: TBD)		$2,251		$2,251	$4,502
Indirect costs:		$2,498		$2,498	$4,997
Subtotal		$7,000		$7,000	$14,000
Direct Costs		$41,029		$41,084	$82,114
Indirect Costs (55.5% on-campus rate, not including tuition and fees)		$18,971		$18,915	$37,886
Total Requested		**$60,000**		**$60,000**	**$120,000**

Student-Related Costs: We request 95% and 94% FTE support for Z. Knorek, a PhD student, in years 1 and 2, respectively. The graduate student fellow will participate in all aspects of the project and be chiefly responsible for day-to-day progress on data collection, processing, analysis, and manuscript/report drafting. This work will form the basis of a dissertation chapter for the graduate student. Benefits are based on the standard 2020 UNC rates of 1.34% of the graduate student's stipend (FICA), and health insurance for the graduate student. Graduate student health insurance and tuition and fees are escalated by 3% in year 2.

Travel: Support is requested for Z. Knorek to travel to an Annual Davidson Fellow Meeting (location and dates TBD) and a national meeting to disseminate project findings (includes registration, airfare, lodging, and per diem) in both years 1 and 2. We have included $2,498.39 as indirect costs to meet the UNC-mandated 55.5% indirect cost rate; this $2,498.39 is included in the indirect costs total.

Indirect Costs: Indirect costs are calculated at 55.5% of direct costs, not including graduate tuition and fees.

The North Carolina Division of Marine Fisheries Coastal Recreational Fisheries Grant we recently secured for January 2020-December 2021 will provide the additional 5% and 6% FTE for the student-related costs on this project in years 1 and 2, respectively.

e. Data Sharing Plan

This project will generate the following environmental information for restored and natural intertidal oyster reefs in the Rachel Carson Reserve: reef area (m^2), reef height (m), site depth (m NAVD88), oyster density (m^{-2}), size-frequency distributions, growth rates (cm/month), survival (# survivors/month), pest presence and prevalence (*Polydora* spp.: mean number of individuals per oyster; *Cliona* spp.: mean proportion of shell length infected), and community assemblage (infauna, invertebrate macrofauna, and juvenile fish abundances and diversity indices). As data are collected, I will share them with my university faculty sponsor and NCNERR staff via Dropbox and will ensure all are shared before the terminus of the Fellowship on July 31, 2022. Data products—namely .csv files and R scripts—along with metadata documentation to read, use, and understand the data and a point of contact for user questions, will be made publicly available at the time of publication in the peer-reviewed literature or July 31, 2023, whichever comes first. I will use Ecological Metadata Language standards when developing my metadata format and content. Moreover, I will publish the methodology for creating these products in the open literature, and will leave the data on free, open-source platforms including GitHub (https://github.com/) and the Carolina Digital Repository (https://cdr.lib.unc.edu/). I will also as the NOAA National Centers for Environmental Information if they have interest in and the resources for archiving the data, and I will work with them as needed. At the time of pre-publication for any manuscript, I will submit the relevant data for that manuscript to the NOAA Institutional Repository (https://repository-library-noaa-gov.libproxy.lib.unc.edu/). The prospective Davidson Fellow, Zofia Knorek, has experience making data publicly available through past studies as a project lead and collaborator. Zofia will work with her faculty sponsor, Joel Fodrie, who has extensive experience making publicly available, to ensure data sharing is accomplished promptly and properly.

f. National Environmental Policy Act

Not Yet Applicable

g. Literature Cited

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c. Resume **Zofia Knorek, Curriculum Vitae**

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Education

2018 –	University of North Carolina at Chapel Hill. *Chapel Hill, NC.* PhD Student in Ecology. Advisors: F. Joel Fodrie and Niels Lindquist. Degree anticipated: 2022.
2016 – 2018	University of Oregon, Oregon Institute of Marine Biology. *Charleston, OR*. Master of Science in Biology. Advisor: Aaron Galloway. GPA: 3.96.
2011 – 2015	Hendrix College. *Conway, AR.* Bachelor of Arts in Biology with Distinction, *Cum Laude.* GPA: 3.77.

Research Experience

2018 –	Oyster reef restoration trajectories in Pamlico Sound and Chesapeake Bay. University of North Carolina at Chapel Hill Institute of Marine Sciences and Smithsonian Environmental Research Center
2016 – 2018	A tale of two tunicates: *Didemnum vexillum* and *Botrylloides violaceus* as biofouling agents in bivalve aquaculture. Oregon Institute of Marine Biology.
2015 – 2016	Citizen science research: Puget Sound Seabird Survey, SoundToxins, Harbor Porpoise Monitoring, Sea Star Wasting Monitoring, etc. *Citizen Science Educator AmeriCorps*. Port Townsend Marine Science Center.
2015	Characterizing the diaphragm of deep-diving beaked whales (*Mesoplodon* spp.). Hendrix College.
2014	A multifaceted, highly resolved investigation into the trophic role of small pelagic fishes on the Northeast US Continental Shelf. Woods Hole Oceanographic Institution.
2013	Microbial diversity in restored urban and natural freshwater habitats in Central Arkansas: A foundation for a research-based curriculum. Hendrix College.

Fellowships and Grants

2020 – 2021	North Carolina Division of Marine Fisheries Coastal Recreational Fisheries License Grant (Co-PI, $145,722)
2019	Graduate and Professional Student Federation of UNC-Chapel Hill Travel Award ($400)
2019	University of North Carolina at Chapel Hill Teaching Fellowship ($1,500)
2019	Smithsonian Institution Fellowship ($7,500)
2019	University of North Carolina at Chapel Hill Teaching Fellowship ($1,000)
2018	University of North Carolina at Chapel Hill Doctoral Merit Fellowship ($53,032)
2017	Dr. Nancy Foster National Oceanographic and Atmospheric Administration Scholarship (Top 15 National Finalist)
2017	National Science Foundation Graduate Research Fellowship (Honorable Mention)
2016 – 2018	University of Oregon Graduate Fellowship ($4,797 per quarter + tuition voucher)
2016	Segal AmeriCorps Education Award ($5,795)
2016	National Science Foundation Graduate Research Fellowship (Honorable Mention)
2011 – 2015	Hendrix College Provost's Scholarship ($135,720)
2014	Watson Fellowship (National Finalist)
2014	Hendrix College Odyssey Research Grant ($4,505)
2014	National Science Foundation Maryland Sea Grant Research Experience for Undergraduates ($6,000; declined to work at WHOI)

Publications

Knorek, Z.R., Hansen, B., Groth, S., Rumrill, S., Galloway, A.W.E. *In Review.* Seasonal variability in a nascent population of a non-indigenous colonial ascidian (*Didemnum vexillum*) near Winchester Bay, Oregon.

Knorek, Z.R. 2018. A tale of two tunicates: *Didemnum vexillum* and *Botrylloides violaceus* as biofouling agents in bivalve aquaculture. University of Oregon. Master's Thesis: http://hdl.handle.net/1794/23754
Suca, J.J., Pringle, J.W., **Knorek, Z.R.**, Hamilton, S.L., Richardson, D.E., Llopiz, J.K. 2018. Feeding dynamics of Northwest Atlantic small pelagic fishes. Progress in Oceanography 165: 52-62. https://doi.org/10.1016/j.pocean.2018.04.014
Knorek, Z.R. 2017. *Lottia pelta*. In: Oregon Estuarine Invertebrates: Rudys' Illustrated Guide to Common Species, 3rd ed. T.C. Hiebert, B.A. Butler and A.L. Shanks (eds.). University of Oregon Libraries and Oregon Institute of Marine Biology, Charleston, OR.
Johnson, A.A., Sutton, J.K., Moran, M.D., **Knorek, Z.R.** 2013. General Zoology Laboratory Directions. Conway, AR: Hendrix College.

Presentations

Knorek, Z.R., Hansen, B., and Galloway, A.W.E. Invasive tunicates as biofouling agents in longline bivalve aquaculture. Pacific Coast Shellfish Growers Association Meeting, Red Lion at Jantzen Beach, Portland, OR. September 2019.
Knorek, Z.R. Invasion of land and sea: Cause and effect. Pub Science Invited Talk, Seven Devils Brewery, Coos Bay, OR. May 2017.
Knorek, Z.R., Whitford, L.N, and Carlson, E.P. Ocean Acidification Study Through Systems and Inquiry Science. Western Society of Naturalists, Hyatt Regency, Monterey, CA. November 2016.

Teaching

2019	Anatomy and Physiology, University of North Carolina at Chapel Hill, *Teaching Assistant*
2019, 2019	Introduction to Marine Sciences, University of North Carolina at Chapel Hill, *Teaching Fellow*, *Co-Instructor*
2018	Conservation Biology, University of Oregon, *Teaching Assistant*
2017, 2018	Marine Conservation Biology, Oregon Institute of Marine Biology, University of Oregon, *Teaching Assistant*
2017	Marine Environmental Issues, Oregon Institute of Marine Biology, University of Oregon, *Teaching Assistant*
2017	Charleston Marine Life Center, Oregon Institute of Marine Biology, University of Oregon, *Graduate Teaching Fellow*
2016	NOAA Bay and Watershed Education Training Program, *Instructor*
2015 – 2016	K-12 Programming, Port Townsend Marine Science Center, *Instructor*
2014 – 2015	Biology Writing Center, Hendrix College, *Assistant*
2013 – 2015	Zoology, Hendrix College, *Tutor, Teaching Assistant*
2014	Marine Biology, Hendrix College, *Teaching Assistant*

Employment and Leadership Experience

2019	UNC-Chapel Hill Graduate and Professional Student Federation, Ecology Senator
2017	South Slough National Estuarine Research Reserve, Volunteer
2016 – 2018	Charleston Marine Life Center, Volunteer
2016 – 2018	Oregon Marine Student Association, Graduate Student Leader
2014 – 2015	Hendrix College Student Senate, Social Committee Chair
2011 – 2015	Hendrix College Department of Admissions and Financial Aid, Student Worker
2014 – 2015	Hendrix College Curriculum Committee, Student Representative

Awards, Distinctions, and Professional Societies

2019 –	National Shellfish Association
2018 –	Sigma Xi Scientific Research Honor Society
2015	Arthur Johnson Biology Award
2012 –	Beta Beta Beta Biological Honor Society

8. Match Waiver

Not Applicable

9. Negotiated Indirect Cost Rate Agreement

Not Applicable

Application

Application ID: 2851648
Applicant: The University of North Carolina at Chapel Hill
Project Title: Evaluating the structural and functional equivalency of natural and restored oyster reefs in the North Carolina National Estuarine Research Reserve
Project Period: 08/01/2020 - 07/31/2022
Total Amount Proposed: $123,879.00
Federal Amount Requested: $120,000.00
Fiscal Year of Federal Funding Requested: 2020
Principal Investigators / Project Directors:

Reviewer 54

Scoring Summary

Total Score: 79

Scoring Details

Score	Range	Criterion
20	0 - 25	Importance/Relevance and Applicability of Proposal to the Program Goals
20	0 - 25	Technical/Scientific Merit
15	0 - 20	Overall Qualification of Applicant
6	0 - 10	Project Costs
13	0 - 15	Outreach and Education
5	0 - 5	Data Management Plan Technical Soundness

Review Criteria

Importance/Relevance and Applicability of Proposal to the Program Goals

This criterion ascertains whether there is intrinsic value in the proposed work and/or relevance to NOAA, federal, regional, state, or local activities.

For the Margaret A. Davidson Graduate Fellowship, this refers to addressing the priority management needs identified by the reserves (https://coast.noaa.gov/nerrs/research/davidson-fellowship.html). Does the proposed work relate to at least one appropriate reserve management need? Does the project demonstrate a sufficient understanding of the relevant coastal management issue? Does the project take an approach that is important to address a specific priority management need?

Comments (Required):
The PI's proposal directly addresses research needs of the NCNERR and more broadly of the oyster restoration community in NC. The PI ties this research not only to NERRs work but for its potential to inform the NC Coastal Habitat Protection Plan and the actions of restoration practitioners. One potential drawback, however, is that many previous studies have shown structural and functional metrics of restored reefs to vary

widely even within small geographic extents. A clearer tie as to how this research addresses that gap would be nice.

Technical/Scientific Merit

This criterion assesses whether the approach is technically sound, if the methods are appropriate, and whether there are clear project goals and objectives.

Is the approach appropriate to address the reserve need and are the stated goals and objectives worthy and achievable within the proposed time-frame? Does the proposed approach incorporate sound science, scientific, and/or technical advancements in the design and implementation of the proposed work? Are the project milestones feasible and are sufficient guidance, support, time, and resources available for the methods proposed to conduct the proposed research?

Comments (Required):
The project questions and hypotheses are very clear. Much appreciated. The methods used are sound to measure both structure and function though execution of those methods is key. I question whether a true measure of function for fishes at least can be elucidated from May through September sampling only during full moon events translating to once a month samples.

Overall Qualification of Applicant

This criterion ascertains whether the applicant possesses the necessary education, experience, training, facilities, and administrative resources to accomplish the project.

Has the applicant articulated significant interest in professional development as part of the fellowship? Does the applicant have the educational background and fortitude needed to successfully conduct this project? Does the application, including letters of support, indicate that the student has the potential to be successful? Do the letters from the faculty advisor demonstrate support for the fellowship?

Comments (Required):
Certainly has the educational background and ability to execute the research

Project Costs

This criterion evaluates the budget to determine if it is realistic and commensurate with the project needs and time-frame.

Is the budget request reasonable and does the applicant justify the proposed budget request? Is the allocation sufficient to cover the travel requirements of the program? Is the allocation sufficient to provide the resources needed to conduct the project?

Comments (Required):

Costs seem reasonable. Since it was mentioned so much in the application and associated materials, it seems odd that there was no good explanation as to how the CRFL funds would be spent vs. the Fellowship funding. Specifically, if the Fellowship would be providing $120,000 over two years for the total 12 month cost of the student stipend/benefits, is that duplicative with the $145,722 from CRFL funding or not? Needs more explanation.

Outreach and Education

This criterion assesses whether the project provides a focused and effective education and outreach strategy regarding NOAA's mission to protect the Nation's natural resources.

Does the project identify potential end-users? Does the project propose a collaborative approach to incorporate the appropriate end-users input into the outcomes and any products? Does the applicant demonstrate knowledge of the target audience? Will the project outputs meet the identified end user needs?

Comments (Required):
Very good connections to the managers, practitioners, and K-12 audiences as proposed.

Data Management Plan Technical Soundness

This criterion assesses whether the Data Management Plan, if required, ensures that the data collected and/or created will be made available to general users in a timely manner free of charge, or at minimal cost.

Project includes a data management plan that ensures that environmental data collected as part of the project will be shared among the fellow, university faculty sponsor, and reserve staff prior to the conclusion of the fellowship. The data management plan should meet the requirement to be visible, accessible, and independently understandable to users in a timely fashion (typically within two years).

Comments (Required):
Data management plan is sound.

Reviewer 95

Scoring Summary

Total Score: 87

Scoring Details

Score	Range	Criterion
21	0 - 25	Importance/Relevance and Applicability of Proposal to the Program Goals
22	0 - 25	Technical/Scientific Merit
19	0 - 20	Overall Qualification of Applicant

9	0 - 10	Project Costs
11	0 - 15	Outreach and Education
5	0 - 5	Data Management Plan Technical Soundness

Review Criteria

Importance/Relevance and Applicability of Proposal to the Program Goals

This criterion ascertains whether there is intrinsic value in the proposed work and/or relevance to NOAA, federal, regional, state, or local activities.

For the Margaret A. Davidson Graduate Fellowship, this refers to addressing the priority management needs identified by the reserves (https://coast.noaa.gov/nerrs/research/davidson-fellowship.html). Does the proposed work relate to at least one appropriate reserve management need? Does the project demonstrate a sufficient understanding of the relevant coastal management issue? Does the project take an approach that is important to address a specific priority management need?

Comments (Required):
The proposed project to evaluate natural and restored oyster reefs addresses two of the stated NERR management needs, improved quantification of ecosystem services, and an examination of the success and ecosystem services provided by habitat restoration efforts. The applicant demonstrates a broad and detailed knowledge of oyster reef structure and function, and has worked on similar projects in other areas. The hypotheses and project goals appear well-aligned with NERRs stated needs. One concern is that these reefs are subject to harvest, and I don't see how differential harvest pressure on the various reefs will be assessed or controlled for when assessing differences in reef structure. This is often a problem with assessment of oyster reef restoration, and would be beneficial to see this addressed. As documented in the proposal, this is a well-studied system, and although this research clearly addresses existing NERRs management priorities, it feels more like a continuation of existing studies than a novel approach that will yield new understanding. The first stated management need of the NC NERRS is linking long-term water quality and weather events, and climate change, to the provision of ecosystem services. This aspect is lacking in the proposed work, which seems like a missed opportunity

Technical/Scientific Merit

This criterion assesses whether the approach is technically sound, if the methods are appropriate, and whether there are clear project goals and objectives.

Is the approach appropriate to address the reserve need and are the stated goals and objectives worthy and achievable within the proposed time-frame? Does the proposed approach incorporate sound science, scientific, and/or technical advancements in the design and implementation of the proposed work? Are the

project milestones feasible and are sufficient guidance, support, time, and resources available for the methods proposed to conduct the proposed research?

Comments (Required):
The proposed research and analyses clearly identify the plan to address the project objectives of comparing the structural and functional characteristics of restored and natural oyster reefs.. The applicant has significant experience working in these systems, and is joining a local research lab with long experience in the study area. Therefore, there is every reason to think that resources will be available to complete the project, and that the methods are appropriate to answer the research objectives. Again, this is a bit of double-edged sword, as a technically sound approach using tried and true research methods does not always provide innovation or technical advancement. However, there is a very high likelihood that the research activities will provide answers to the stated objectives, and the assessment of long-term reef restoration structure and funition is a valuable approach. The proposal also addresses the need to quanitify ecosysterm services provided by restored and natural habitats. Oyster reefs have numerous ecosystem services, including the value of the oysters themselves, fish habitat, erosion protection, denitrification/phytoplankton removal for quality. The proposed work will measure fishery utilization using traps and gill nets, and will estimate filtration using an existing tool based on live oyster cover. I would have liked to see an attempt to incorporate the N and phytoplankton removal capacity of oysters in the ecosystem services assessment.

Overall Qualification of Applicant

This criterion ascertains whether the applicant possesses the necessary education, experience, training, facilities, and administrative resources to accomplish the project.

Has the applicant articulated significant interest in professional development as part of the fellowship? Does the applicant have the educational background and fortitude needed to successfully conduct this project? Does the application, including letters of support, indicate that the student has the potential to be successful? Do the letters from the faculty advisor demonstrate support for the fellowship?

Comments (Required):
This applicant has excellent recommendations from her current faculty adviser as well as advisors from previous positions. They all note her ambition , creativity, work ethic, and ability to conceive and execute valuable research projects, and it is clear from her academic and work experience that the applicant is fully capable of completing an excellent project. She is interested in applying scientific research results to management needs, and her long-term career goals are in policy and science communication. I believe she will be effective in networking with the local science and educational community. One potential shortfall is that as she has concentrated on working on oyster-related studies in all of her post-college work experiences, she may be lacking the breadth of an interdisciplinary scientist. I hope she will take the opportunity to collaborate with graduate students from diverse fields during her PhD program.

Project Costs

This criterion evaluates the budget to determine if it is realistic and commensurate with the project needs and time-frame.

Is the budget request reasonable and does the applicant justify the proposed budget request? Is the allocation sufficient to cover the travel requirements of the program? Is the allocation sufficient to provide the resources needed to conduct the project?

Comments (Required):
Budget request is reasonable and sufficient. The project benefits from other funded projects that will contribute supplies and personnel to help with the field work. Fieldwork is local.

Outreach and Education

This criterion assesses whether the project provides a focused and effective education and outreach strategy regarding NOAA's mission to protect the Nation's natural resources.

Does the project identify potential end-users? Does the project propose a collaborative approach to incorporate the appropriate end-users input into the outcomes and any products? Does the applicant demonstrate knowledge of the target audience? Will the project outputs meet the identified end user needs?

Comments (Required):
The proposal identifies multiple end-users of the research, including TNC, state natural resource agencies, and non-profits involved in oyster restoration. A link to the state's Oyster Blueprint program is also mentioned, and this would be a valuable outlet. The applicant has experience in citizen science and working with school-aged children, and notes working with the local school system to develop an oyster reef program. However, there is not a statement that the research will be incorporated into existing NERRs outreach and education programs, including the Coastal Training program, and the diverse educational workshops held at the Reserve. Specific outreach through the NC NERR should be conducted.

Data Management Plan Technical Soundness

This criterion assesses whether the Data Management Plan, if required, ensures that the data collected and/or created will be made available to general users in a timely manner free of charge, or at minimal cost.

Project includes a data management plan that ensures that environmental data collected as part of the project will be shared among the fellow, university faculty sponsor, and reserve staff prior to the conclusion of the fellowship. The data management plan should meet the requirement to be visible, accessible, and

independently understandable to users in a timely fashion (typically within two years).

Comments (Required):
A thorough data management plan utilizing both University and NOAA repositories will be used, as well as sharing data with NC NERRS.

Reviewer 96

Scoring Summary

Total Score: 75

Scoring Details

Score	Range	Criterion
20	0 - 25	Importance/Relevance and Applicability of Proposal to the Program Goals
19	0 - 25	Technical/Scientific Merit
12	0 - 20	Overall Qualification of Applicant
9	0 - 10	Project Costs
11	0 - 15	Outreach and Education
4	0 - 5	Data Management Plan Technical Soundness

Review Criteria

Importance/Relevance and Applicability of Proposal to the Program Goals

This criterion ascertains whether there is intrinsic value in the proposed work and/or relevance to NOAA, federal, regional, state, or local activities.

For the Margaret A. Davidson Graduate Fellowship, this refers to addressing the priority management needs identified by the reserves (https://coast.noaa.gov/nerrs/research/davidson-fellowship.html). Does the proposed work relate to at least one appropriate reserve management need? Does the project demonstrate a sufficient understanding of the relevant coastal management issue? Does the project take an approach that is important to address a specific priority management need?

Comments (Required):
This project is directly applicable to the restoration needs for the NC NERR in that it addresses the analyses and synthesis of the successes of oyster restoration, especially intertidal oysters. This project also relates to the ecosystem services of oyster reefs.

Technical/Scientific Merit

This criterion assesses whether the approach is technically sound, if the methods are appropriate, and whether there are clear project goals and objectives.

Is the approach appropriate to address the reserve need and are the stated goals and

objectives worthy and achievable within the proposed time-frame? Does the proposed approach incorporate sound science, scientific, and/or technical advancements in the design and implementation of the proposed work? Are the project milestones feasible and are sufficient guidance, support, time, and resources available for the methods proposed to conduct the proposed research?

Comments (Required):
This proposal has very clear questions to be answered. I do wonder how the applicant will determine if a restored reef has reached equivalency to a natural reef, if some of the factors conflict. In other words, If results show biophysical factors to be equivalent to natural reefs but the functional factors (group density, biomass, diversity) are not equivalent; how will overall equivalency be determined? The timeline seems reasonable but question the need for both the 20 yr and 23 yr replicates. The applicant may want to consider dropping one of these groups. The lab workup of such a wide community assemblage may be very time consuming. Just a suggestion, not a make or break on the funding of this proposal. Gill nets should be described with a mesh size, not a slit size (stretch mesh?) or bar. How deep will the hand excavation go within the .25 m square? Since this really only addresses intertidal reefs in one reserve, the results are most likely only applicable to Back Sound and possibly south where oysters are mostly intertidal. These results will not likely be applicable to the Pamlico Sound oyster ecosystem services (subtidal) as stated in the expected outcomes.

Overall Qualification of Applicant

This criterion ascertains whether the applicant possesses the necessary education, experience, training, facilities, and administrative resources to accomplish the project.

Has the applicant articulated significant interest in professional development as part of the fellowship? Does the applicant have the educational background and fortitude needed to successfully conduct this project? Does the application, including letters of support, indicate that the student has the potential to be successful? Do the letters from the faculty advisor demonstrate support for the fellowship?

Comments (Required):
Seems like only recent work has been in oyster restoration within all of the applicant's work.

Project Costs

This criterion evaluates the budget to determine if it is realistic and commensurate with the project needs and time-frame.

Is the budget request reasonable and does the applicant justify the proposed budget request? Is the allocation sufficient to cover the travel requirements of the program? Is the allocation sufficient to provide the resources needed to conduct the project?

Comments (Required):
Costs seems reasonable

Outreach and Education

This criterion assesses whether the project provides a focused and effective education and outreach strategy regarding NOAA's mission to protect the Nation's natural resources.

Does the project identify potential end-users? Does the project propose a collaborative approach to incorporate the appropriate end-users input into the outcomes and any products? Does the applicant demonstrate knowledge of the target audience? Will the project outputs meet the identified end user needs?

Comments (Required):
Outreach to the various agencies who are collaborating on oyster restoration is good and educational strategies are good since educational products will be developed.

Data Management Plan Technical Soundness

This criterion assesses whether the Data Management Plan, if required, ensures that the data collected and/or created will be made available to general users in a timely manner free of charge, or at minimal cost.

Project includes a data management plan that ensures that environmental data collected as part of the project will be shared among the fellow, university faculty sponsor, and reserve staff prior to the conclusion of the fellowship. The data management plan should meet the requirement to be visible, accessible, and independently understandable to users in a timely fashion (typically within two years).

Comments (Required):
Seems to meet the requirements